mination. For example, stratification could increase the speed of germination for the families with slower rates of germination, and families such as tree 1 should be routinely stratified. However, tree 2 would not benefit from stratification. In a mix of such families, stratification would increase overall uniformity.

The greatest differences between germination of these seed lots occurred during the first 4 to 10 days of germination. As the study progressed, cumulative germination increased and differences between seed lots gradually decreased. The results indicate, however, that both the germinative energy and the germinative capacity are related to the genotype of the parents.

The Weibull function appears to be useful in quantifying tree seed germination. Furthermore, the parameters associated with the function are valid response variables for consideration in an analysis of variance (Rink *et al.* 1979). The advantage of the Weibull function in describing the germination process of pines is that the function smoothes out the cumulative germination curve for visual or statistical comparison of particular sources of seed germination. Furthermore, the parameters a, b, and c can also be used as response variables.

Nurserymen and tree breeders could improve speed and uniformity of germination through recurrent selection but would have to weigh potential benefits against possible gains or losses in other genetic characteristics of the seed supply. The general lack of specific combining ability of seed lots in this study suggests that little could be gained by specific crosses for seed germination. The strong maternal influence could be a very valuable source of control of seed germination. Individual families of wind-pollinated seedlings would have more uniform germination than mixed seed lots and would certainly be expected to produce greater uniformity in nursery beds. The strong maternal influence could also be useful in the selection of female parent trees for controlled pollinations. Females that consistently produced highly viable seed with favorable germination records would be most desirable as progeny test female parents.

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Sensitivity of Seed Germination and Seedling Root Growth to Moisture Stress in four Provenances of Pinus halepensis Mill.

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Summary

The effects of water potential of the substrate on germination and on the first stage of root growth in seeds from four sources (Israel, Marocco, Greece and Italy) of *Pinus halepensis* Mill. have been studied.

They were kept for thirty days in light (16 hours photoperiod at 10.000 lux) and at the temperature of 20 ± 0.5° C. The water potentials between 0 and −8 bars are obtained by the use of polyethylenglycol solution (PEG 6.000).

Germination energy, germination rate and root growth appear to be substantially different in the four sources.

Significant reduction of germination percentage and of germination value (GV) are already observed at −2 bars, while root growth, which appeared to be less susceptible to water stress, is affected only at −4 bars.

The behaviour of the four provenances under stress was very differentiated: the water potential which induces significant reductions of germination percentage and of root growth varies from −2 bars to −6 bars in the more or less susceptible provenance, respectively.

The survival ability of the seedlings under situations of water stress, also estimated in respect to root growth, showed to be significantly different between the provenances.

The results are also discussed in relation to the climatic conditions of the zones of seed origin.

Key words: Pinus halepensis, provenances, moisture stress, germination, root growth.

Zusammenfassung

Es wurde der Einfluß des Wasserpotentials des Substrats auf die Keimung und die erste Wurzelentwicklung bei 4 Saatgutherkünften von *Pinus halepensis* Mill. aus Israel, Marokko, Griechenland und Italien untersucht. Die Keimung erfolgte bei 20 ±0.5° C unter 16stündiger Tagesbelichtung mit 10000 lux über 30 Tage. Die Wasserpotentiale zwischen 0 und −8 Bar wurden durch Polyäthylenglycol-Lösungen (PEG 6000) erreicht. Keimkraft, Keimprozent und erstes Wurzelwachstum waren bei den 4 Herkünften unterschiedlich. Das Keimprozent sank schon bei −2 Bar, während das Wurzelwachstum, welches vom Wasserstreß weniger beeinflußt wurde, erst bei −4 Bar reagierte. Die 4 Provenienzen verhielten sich unter Streßbedingungen sehr unterschiedlich, d. h. dasjenige Wasserpotential, welches das Keimprozent und das Wurzelwachstum signifikant negativ beeinflußte, variierte bei den Provenienzen von −2 bis −6 Bar. Die Überlebensfähigkeit der Keimlinge zeigte unter Wasserstreß ebenfalls signifikante Provenienzunterschiede. Die Ergebnisse werden auch im Zusammenhang mit den klimatischen Bedingungen in den Saatgutursprungsgebieten diskutiert.

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Introduction

The inhibition of germination by water stress in seeds of several species is well documented (KAUFMANN and ROSS, 1970; HEGARTY and ROSS, 1978; ROSS and HEGARTY, 1979) and some metabolic modifications, presumably linked to this inhibition, are known (WILSON and HARRIS, 1968; JONES, 1969; JONES and ARMSTRONG, 1971; WILSON, 1971).

Some species have shown a different sensitivity to water stress as regards germination and the subsequent root growth; such processes seem to have different and separate metabolic control (HEGARTY and ROSS, 1979a, 1979b; ROSS and HEGARTY, 1979).

Relatively little research has been carried out on the effects of water stress upon germination in tree species (BONNER and FARMER, 1966; BARNETT, 1969; KAUFMANN and ECKHARD, 1977), and still less on the germination and development of roots (LARSON and SHUBERT, 1969; DJAVANSHIR and REID, 1975).

Furthermore, the information concerning the behaviour of cultivars and different provenances within the same species is very scanty (SPRINGFIELD, 1966; HEGARTY and ROSS, 1979b).

However the importance of resistance to drought, for the germination and establishment of the seedlings, is clear from the literature; it is also possible that the intraspecific variations of this tolerance be quite remarkable, at least in species with a large distribution.

In the present work, the effects of water stress induced by the application of PEG(1) solution on the germination and on the first stages of root growth in four provenances of *Pinus halepensis* MILL. are examined.

Materials and Methods

The seeds of *Pinus halepensis* MILL., three years old, come from collections carried out in the regions indicated in *Table 1*, within the project 4 bis FAO "International experiences on provenances of *Pinus halepensis* and *Pinus brutia*" (PELIZZO and TOCCI, 1978. The seeds has been stored in closed containers at 3—4° C with a moisture content of 7.5—9.0%. Germination periodic tests have not shown noticeable changes during storage. Damaged and very small seeds have been eliminated, but not the empty ones, as we decided not to use the method of floating in n-pentane (MCLEMORE, 1965), which in previous tests had reduced germination.

The number of seeds in the four replications of every thesis was adjusted by taking into consideration the percentage of full seeds previously found in each provenance. The number of empty seeds, in any case, was calculated at the end of the experiment and the results were expressed in terms of % of full seeds (47—52 full seeds for every replication).

Germination taken as number of seeds with 2 mm long positively geotropic radicle, was recorded with daily counts.

The water potential of the germination substrates (0, −2, −4, −6, −8 bars) was evaluated using a PEG 6000 solution (m. w. 5000—7000) Merk, prepared as described by MICHEL and KAUFMANN (1973).

Germination occurred in polystirol germinators, 12 cm in diameter, on filter paper saturated in the PEG 6000 solutions. In order to keep the water potential unchanged during the whole test, paper and solutions were changed every four days.

(1) — PEG = polyetylenglycol

Table 1. — List of *Pinus halepensis* MILL. provenances.

Provenance	Country	North lat.	Long.	Altitude (m)
A3 Euboea	Greece	38°58'	23°18'E	150-200
A6 Shaharia	Israel	31°36'	34°50'E	200
A15 Tamga Zaouia	Marocco	32°02'	6°07'W	2000
A25 Imperia	Italy	43°54'	8°03'E	200

The germinators were kept in climatic cells at the constant temperature of 20 ± 0.5° C, with a photoperiod of 16 hours and light intensity of 10000 lux.

The test lasted 30 days, with daily check on the germination and final measurements of the lengths of root and of hypocotyl of germinated seeds. For the germinated seeds at 0 and −2 bar (and, only for the provenance A3, also at −4 bar), at the end of the test fresh and dry weight and the percentage of water of the roots were calculated.

The germination percentage, the mean germination time (COME, 1970) and the germination value (DJAVANSHIR and POURBEIK, 1976) were calculated. To calculate GV, the formula by DJAVANSHIR and POURBEIK (1976) has been used in preference to the one by CZABATOR (1962) because it is thought to be more suitable to give a reliable estimate of subsequent survival of the seedlings, at least for the genus Pinus. Mean daily increases in root growth were calculated as ratio between average length of roots at the end of the test and average time from germination.

Percents were transformed to arcsin $\sqrt{\text{percentage}}$ for statistical analysis. Results were analyzed by factorial analysis. Means were compared with LSD calculated with t 0.01.

Results and discussion

a) Germination

The reduction of the water potential of the germination substrate diminishes considerably the germination percentages already at −2 bar *(Table 2)*. The germination capacity in the various sources is substantially similar. However the reaction to variations of the water potential in seeds from the four provenances is different: A3 differs almost always significantly from the others *(Table 2)* and these differences are already evident at −2 bar. A3, therefore, seems to be the most resistant, with a tolerance threshold between −4 and −6 bar, A15 the least resistant, with a tolerance threshold between 0 and −2 bar.

Appreciable resistance is shown also by A25 which has similar behaviour to A3; however, in this provenance, susceptibility to high water stress is more noticeable.

Speed of seed germination is significantly different in the four provenances and is markedly influenced by water potential *(Table 3)*; moderate stress, such as −2 bar, already causes a significant increase of the mean germination time. The effect of water stress seem more noticeable as regards rate rather than germination capacity, for example in A3 which also for this aspect seems to be the most resistant source *(Table 3)*, the tolerance threshold being between −2 and −4 bar.

The lowest tolerance is again seen in A15, but also in A25.

The provenances with the best results at 0 bar appeared to be A3 and A15, whose behaviour under osmotic stress is opposite also in this case.

In terms of GV *(Table 4)* seed tolerance from all sources appears inferior to that based on the germination percentages or on the mean germination time: for all sources the threshold seems to be between 0 and −2 bar. The response of the four provenances to variations is, however, fairly different; the decrease in GV at −2 bar is clearly higher in A15, the variations of the other being similar up to −4 bar. At the lower potentials (−6 and −8 bar), A3 differs from the other provenances and with almost all the water stresses tried, it differs significantly from all the other provenances.

In order to check possible inhibition or permanent damage caused by PEG solutions, at the end of the test (30 days) the non germinated seeds at −8 bar from all provenances were transferred to germinators with water saturated paper, and further germination was checked for a seven-days period. The seed response was very rapid, so much so that the maximum germination was obtained in 5 days.

The total percentage of germination was compared with germination at 0 bar on the thirtieth day. In provenances resulting as more resistant to water stress (A3 and, at a slightly minor level, A25), the two values do not differ, which confirms the existence in these provenances of a good survival tolerance. In the light of these results, the major susceptibility to low water potential of A25 in respect to A3 should be attributed not so much to real metabolic damage as to the inability to start growth (in particular extension growth) under a certain threshold of water potential, according to a mechanism already shown by other species (Hegarty and Ross, 1978; Ross and Hegarty, 1980); this mechanism would make the inhibition of germination by water stress similar to certain types of seed dormancy (Haber and Luippold, 1960).

In the less resistant provenances and in particular A15, the difference between the two values is very high (69.3% against 99.0%). The cause of this result have not been further examined, but presumably there have been profound metabolic modification in seeds from this provenance wich can be interpreted as real damage and not as regulative responses.

b) Root growth

The effect of water stress on root length at the end of the experiment were already evident at −2 bar; this is due mainly to the strong reduction of growth occurring in A15, which has also shown, from this point of view, to be the less resistant provenance, while A3 is the most resistant *(Table 5).*

The average root length in the seeds germinated at 30 days cannot be used as index of resistance to water stress

Table 3. — **Effects of water potential on mean germination time of seeds from four provenances of *Pinus halepensis* Mill.**

Provenance	Water potential (bars)					
	0	−2	−4	−6	−8	Average
A3	8,48	10,94	14,86	19,31	20,65	14,85
A6	13,22	15,51	18,59	18,44	25,10	18,17
A15	10,50	14,12	18,54	20,25	26,18	17,92
A25	12,40	16,61	19,74	25,03	26,06	19,97
Average	11,15	14,29	17,93	20,76	24,50	

LSD 0,01. Within the table 3,02; for provenances average 1,35; for PEG average 1,50.

of the process of root growth, because it is influenced by the germination rate.

The root length at the end of period of water stress can, however, be used, together with GV, as indication of establishment capacity of the seedlings: Djavanshir and Reid (1975) have shown that in the genus Pinus seedlings with roots of less than 20 mm at the end of period of water stress, cannot survive when transplanted.

In *Fig. 1* percentages of seedlings with roots longer than 20 mm are plotted against the germination and growth potentials for all provenances· The difference in behaviour between the provenance A3 and provenance A15 is evident.

Behaviour similar to A3 as regards water potential can also be found in A6 and A25. In this last source absolute values are very low. This particular trait (short root) cannot be attributed only to slow germination: at 0 bar the mean germination time of A25 does not differ significantly from the mean germination time of A15 and not even from the mean germination time of A3 at −4 bar *(Table 3),* while the corresponding root lengths *(Fig. 1)* are very different.

Also for A15 the strong decrease at -2 bar *(Fig. 1)* cannot be referred to the slower germination at this water potential. At 0 bar the mean germination time for A3 and A15 are not significantly different, also similar are the percentage of roots longer than 20 mm; mean germination time for A15 at -2 bar and for A3 at -4 bar are again similar *(Table 3)* while the corresponding root lengths are different *(Fig. 1).*

Variations of mean daily increment in root growth *(Table 6)* confirm that a different susceptibility exists in the four provenances. Growth ability in four provenances is different (at 0 bar only A3 and A15 do not differ) and is differently modified by stresses, so much so that in the average of the water potentials studied, A3 differs from all other provenances.

Table 2. — **Effects of water potential on germination of *Pinus halepensis* Mill. from four provenances. Percent values with angular transformation in brackets.**

Provenance	Water potential (bars)					
	0	−2	−4	−6	−8	Average
A3	94,10(76,37)	97,00(83,02)	92,50(73,81)	65,00(54,15)	63,64(53,01)	82,45(68,07)
A6	90,10(74,76)	84,70(67,84)	62,20(52,66)	25,50(30,00)	11,80(18,76)	54,86(48,80)
A15	99,00(87,15)	68,70(55,93)	51,10(45,56)	21,30(25,93)	13,00(20,44)	50,62(47,00)
A25	82,10(66,18)	83,17(65,99)	74,20(59,62)	23,70(28,65)	14,40(22,03)	55,51(48,50)
Average	91,33(76,12)	83,39(68,19)	70,00(57,91)	33,88(34,68)	25,71(28,56)	

LSD 0,01 for angular transformation. Within the Table 14.08; for provenances average 6.30; for PEG average 7.04

Table 4. — **Effects of water potential on germination value (GV) of seeds from four provenances of *Pinus halepensis* Mill.**

Provenance	Water potential (bars)					
	0	-2	-4	-6	-8	Average
A3	66,30	45,52	26,09	11,02	11,07	32,00
A6	34,27	24,78	13,67	2,10	0,39	15,04
A15	52,92	18,78	7,44	1,41	0,46	16,20
A25	32,09	22,11	13,56	0,88	0,57	13,84
Average	46,39	27,80	15,19	3,85	3,12	

LSD 0,01. Within the table 9,08; for provenances average 4,06; for PEG average 4,54.

Susceptibility to water stress of root growth appears inferior to sensibility of germination. Significant reductions appear only at -4 bar *(Table 6)* against -2 bar for germination percentage, GV and mean germination time *(Tables 2,3,4)*; at lower potentials reduction is inferior: for example, at -8 bar the daily growth rate of roots is about 26% of the rate at 0 bar, GV being limited to 7%.

The variations caused by stress on the fresh and dry weight of the roots and on the water content have been only analyzed for the 0 and -2 bar level *(Table 7)* and, limitedly for A3 provenance, also for -4 bar *(Table 8)*.

Behaviour under water stress of the various provenances as regards fresh and dry weight is substantially similar to that based on the mean daily increment in root growth *(Table 6)* but with a more noticeable susceptibility to water stress: at -2 bar the reduction (particularly of fresh weight) is already evident *(Table 7)* and this susceptibility is confirmed by results at —4 bar *(Table 8)* in provenance A3. In this last source, on the contrary, rate of root growth does not show significant reduction up to -6 bar *(Table 6)*.

A significant interaction between provenances and water stresses has been seen for the percentage of water content in the roots. The provenances which is most affected by reduction of the water potential is A3 *(Table 7)*. It is possible that this is the consequence of an adaptation capacity of the roots of this provenance, by means of mechanism of modification of the turgidity threshold (which, under weak stresses, would allow growth, although with reduced turgidity) or of osmoregulation, which are mechanism already seen in the roots (Hsiao, 1973). In fact, it has been noted that rate of root growth in A3 does not show significant reduction up to -6 bar and at -2 bar it is even higher than at 0 bar *(Table 6)*.

Conclusion

Leshem (1966) found different types of damages, both on roots and leaves, in seedlings of *Pinus halepensis* Mill.

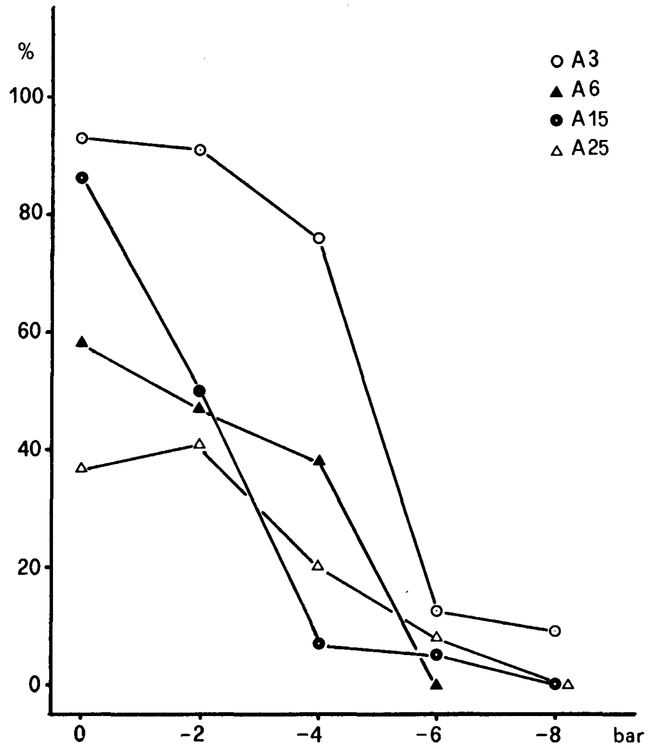

Figure 1. — **Effects of water potential on the percentage of roots with length superior to 20 mm at the end of thirty day period of germination of *Pinus halepensis* Mill. seeds from four provenances**

grown in nutrient solution with PEG 400 and PEG 1500 added; damages were so important to exclude the use of such chemicals to induce water stress. On the other hand in the most recent literature (Parmar and Moore, 1968; Kaufmann and Ross, 1970; Michel and Kaufmann, 1973) it has been reported that polyethyleneglycols are particularly useful to simulate the effects of natural water stress on germination.

Resistance to reduction of water potential observed in *Pinus halepensis* Mill. seems rather low when compared with resistance shown by other species of the genus *Pinus* (Barnett, 1969; Larson and Shubert, 1969; Kaufmann and Eckard, 1977). However, this comparison seems to be difficult because of the differences in techniques applied to evaluate and to induce the water potential. The use of mannitol and PEG of low molecular weight, often used in this kind of research, could have greatly influenced the final results because of the possibility of absorption or the induction of remarkable osmotic adjustments. This has been well documented for these chemicals by Kaufmann

Table 5. — **Average length of roots (mm) in *Pinus halepensis* Mill. seeds from four provenances, germinated and grown on substrates with different water potential.**

Provenance	Water potential (bars)					
	0	-2	-4	-6	-8	Average
A3	53,87	55,48	30,43	5,75	4,83	30,07
A6	29,06	21,58	9,03	4,47	2,26	13,28
A15	54,98	27,51	7,63	4,77	1,87	19,35
A25	16,59	15,97	8,27	2,35	1,65	8,96
Average	38,62	30,14	13,84	4,33	2,65	

LSD 0,0I. Within the table 9,51; for provenances average 4,26; for PEG average 4,76.

Table 6. — **Mean daily increase in growth (mm) of roots in *Pinus halepensis* Mill. from four provenances, germinated and grown on substrates with different water potentials.**

Provenance	Water potential (bars)					
	0	-2	-4	-6	-8	Average
A3	2,52	3,00	2,00	0,56	0,57	1,73
A6	1,71	1,49	0,82	0,37	0,58	0,99
A15	2,79	1,67	0,70	0,46	0,59	1,24
A25	0,95	1,22	0,84	0,51	0,32	0,77
Average	1,99	1,84	1,09	0,47	0,51	

LSD 0,0I. Within the table 0,60; for provenances average 0,27; for PEG average 0,30.

Table 7. — Fresh weight (mg/dm) and dry weight (mg/dm) and water content (%) of roots in seeds of *Pinus halepensis* Mill. from four provenances, germinated and grown on substrates with different water potentials.

Provenance	Water potential (bars)								
	0			-2			Average		
	f.w.	d.w.	%	f.w.	d.w.	%	f.w.	d.w.	%
A3	40,48	4,85	87,97	19,97	4,98	75,04	30,23	4,92	81,50
A6	42,92	5,42	87,17	23,33	4,49	80,70	33,12	4,95	83,93
A15	48,06	5,64	88,28	27,03	5,06	81,12	37,55	5,35	84,20
A25	46,91	5,08	89,15	22,17	3,94	82,18	34,54	4,51	85,66
Average	44,59	5,25	88,14	23,13	4,62	79,76			

LSD 0,0I fresh weight. Provenances average 5,50; PEG average 3,89.
LSD 0,0I dry weight. Provenances average 0,65; PEG average 0,46.
LSD 0.0I water content (%). Within the table 2,90; for provenances average 2,05; for PEG average 1,45.

Table 8. — Fresh weight (mg/dm), dry weight (mg/dm) and water content (%) of the roots of *Pinus halepensis* Mill. seeds from provenance A3, germinated and grown on substrates with different water potentials.

Bars	fresh weight	dry weight	% of water
0	40,48	4,85	87,97
-2	19,97	4,98	75,04
-4	20,29	5,40	73,25
LSD 0,01	8,16	1,28	4,17

and Eckard (1971) and Michel (1971). Such problems should be negligible in the case of high molecular weight PEG, solutions of which can satisfactorily simulate situations of water stress in the field (Kaufmann and Ross, 1970) at least as regards the effects on germination capacity.

Using PEG 4000 Djavanshir and Reid (1975) have found in *Pinus ponderosa* a much lower resistance to that found, using PEG 400, by Larson and Shubert (1969); this resistance is anyway comparable to that found by us in *Pinus halepensis*.

Germination and initial growth phases of the seedlings appeared to be fairly different in the four provenances of *Pinus halepensis* studied. Provenances A3 and A15 are characterized by high germination energy, high germination rate and rapid root growth; provenance A6 gives high germination energy and remarkable slowness of germination and root growth; provenance A25 shows lower germination energy, slow germination and reduced capacity of root growth.

The most important differences of behaviour under stress have been observed precisely in A3 and A15, characterized by the highest capacity both of germination and root growth.

The climatic differences of the zones of origin can explain this behaviour, the higher amount of spring rain in the area of A15 and the higher temperature in that of A3. The last comes from a zone under an attenuate thermo-mediterranean climate, with a number of biologi cally dry days per year estimated between 100 and 150; A 15 belongs to an attenuate meso-mediterranean climatic zone, with mountain type climatic influences, and with a yearly number of biologically dry days between 45 and 75 (UNESCO-FAO, 1963; Walter and Lieth, 1967).

The conditions of test and, in particular, the applied temperature, could have caused the different behaviour of seeds of the two provenances under water stress. Magini (1955) reports between 17.5° and 19° C as being the ideal temperature for germination in *Pinus halepensis*. Personal remarks (data not published) have shown different thermic needs in the seeds of different provenances.

A temperature of 20° C is nearer to the optimum temperature for A3, rather than that of A15 and this may have influenced the response of A15, the difference being however very slight.

In facts, in some species the existence of an interaction between temperature and water stress has been shown (Bonner and Farmer, 1966).

The initial stages of root growth seems to be less susceptible than germination to the reduction of water potential. This situation has been documented in numerous species (Hegarty and Ross, 1979a; Ross and Hegarty, 1979) and in our tests it has been confirmed in each of the sources studied, with the exception of A15, in which there are significant reductions both on germination and on growth already at -2 bar, which confirms the limited resistance of the provenance.

The possibility of the root to maintain growth under water stress is probably linked to high capacity of osmotic adjustment (Hsiao, 1973), which is then responsible for the change, sometimes seen, in the stem/root relationship in plants put under water stress (Hoffman *et al.*, 1971; Hsiao, 1973).

The difference in root system in seedlings germinated and grown under water stress is very evident.. At the two extremes we find again the provenances A3 and A15 (*Fig. 1*). On the basis of criteria proposed by Djavanshir and

REID (1975) to evaluate the survival capacity of the seedlings, it could be concluded that these two provenances are characterized by a significantly different tolerance to drought.

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Genetic Variability Within Douglas-fir Populations: Implications for Tree Improvement

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Summary

Genetic variances and covariances for growth potential, phenology and patterns of first year elongation were calculated from 30 half-sib families from each of three contrasting populations. Analyses of 4-year old trees growing in a single environment revealed high levels of additive genetic variance within populations. As a consequence, rather high estimates of genetic gains in growth potential were associated with weak selection intensities. However, genetic correlations were strong. Gains in growth potential were associated with delayed bud set and increased susceptibility to early fall frosts. For tree improvement to increase the growth potential of Douglas-fir without inadvertent degeneration of adaptation, selections must be based on several traits.

Key words: Douglas-fir, tree improvement, genetic variability, adaptive strategy

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Zusammenfassung

Es wurden genetische Varianzen und Kovarianzen für Wuchspotential, Phänologie und Schemata der Sproßstrekkung im ersten Jahr bei 30 Halbgeschwister-Familien aus drei Kontrast-Populationen abgeschätzt. Durch eine Analyse 4-jähriger Bäume, die in derselben Umwelt aufwuchsen, wurden hohe Niveaus von additiv genetischer Varianz innerhalb der Populationen festgestellt. Die Folge davon waren relativ hohe Schätzwerte für die genetischen Gewinne im Wuchspotential, verbunden mit geringen Selektionsintensitäten. Die genetischen Korrelationen waren jedoch stark. Der genetische Gewinn im Wuchspotential stand in Relation zu der Bildung der Endknospe und einer damit verbundenen zunehmenden Frühfrostempfindlichkeit. Für eine Züchtung zur Verbesserung des Zuwachspotentials der Douglasie ohne versehentliche Entartung, was die Anpassungsfähigkeit betrifft, müssen Selektionen auf mehreren Merkmalen basieren.

Introduction

As a product of environmental selection, the genetic system exhibits variability at many levels: within indivi-